

THE GEOLOGICAL HISTORY OF THE GOURITZ RIVER SYSTEM.

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(Plate III.)

The main watershed of the Colony lies between those rivers which flow north and west into the Atlantic, and those which flow south and east into the Indian Ocean. The watershed is remarkably simple and regular in form considering its length, in fact it approaches the theoretical form assumed by the watershed of a simple anticlinal uplift. Leaving the extreme south-west of the Colony out of account, owing to some special conditions which have complicated the problem there, we may trace the watershed from the mountains near Tulbagh eastwards to the neighbourhood of Matjes Fontein, then north-east along the Klein Roggeveld, Komsberg and Nieuweveld Ranges, round and between the head streams of the Gamka and Zak Rivers, thence across to the Sneeuw Bergen, Achter Rhenoster Bergen, Kikvosch Berg, down considerably to the south along the Bamboos Mountains, and thence along the Stormberg to the Drakensberg. The general course is somewhat east of north-east. The rivers with which we are at present concerned are those which flow south from the Nieuweveld, Komsberg, and Klein Roggeveld, and their tributaries, which enter the ocean by the Gouritz River.

The principal rivers of the drainage basin are the Buffel's, Dwyka, and Gamka Rivers north of the Zwartebergen; of these the two latter join north of the Gamka Poort and flow through the Zwartebergen together; between the Zwartebergen and Langebergen the Buffel's River is joined by the Touw's River, and the Gamka by the Oliphant's River; the two greater streams thus formed unite to make the Gouritz, which traverses the Langebergen and continues its course to the ocean without being joined by any considerable stream south of that range.

The Buffel's, Dwyka, and Gamka Rivers drain the Mordenaar's

Karoo and Gouph, districts which lie between 1,200 and 4,000 feet above the sea; they then traverse the Zwartbergen, a range of which the average height is about 5,000 feet above the sea, and after passing through a mountainous tract between the Zwartbergen and Langebergen they traverse the latter range.

It is clear that some explanation of this arrangement must be found, for the rivers might have been expected to avoid the Zwartbergen and run eastwards to the ocean along the country of moderate elevation that lies north of this mountain belt.

To enable a further discussion of the river system to be made, some important points in the geological history of the country between the watershed and the coast must be considered.

It is now known that the anticlines of the Zwartbergen, and in all probability all the other great anticlinal folds which lie east and west on the south of the Karroo, owe their origin to movements in the earth's crust which took place after the lower parts of the rocks of the Karroo System were deposited: this fact is proved by the occurrence of these rocks to the south of the Langebergen between Worcester and Robertson, where they are involved, together with the Cape System, in the folds produced by those movements, and by the presence of outliers of the lowest division of the Karroo System between the Zwartbergen and Langebergen.

It will be convenient to call the movements of the earth's crust which folded the rocks in the south of the Colony the Zwartberg movements; the folds produced by this great crumpling trend nearly east and west. It is important that they should be clearly separated in our minds from the movements which gave rise to the Cederberg anticline near the west coast. The Cederberg anticline trends some degrees west of north, and was in part produced somewhat earlier than the Zwartberg folds, for the Karroo System transgresses unconformably over the rocks affected by the Cederberg movements, but lies conformably upon the rocks affected by the Zwartberg movements.

It is certain that the Zwartberg movements were completed before the deposition of the Uitenhage Series, for the latter rests unconformably upon the rocks disturbed by those movements; whether the Zwartberg folds were produced during or after the deposition of the upper parts of the Karroo rocks is an unsettled question, but it is not unlikely from the fact that the dolerite sheets and dykes so abundant in the Karroo do not occur in the districts where the rocks have been affected to an appreciable extent by the Zwartberg movements, that these movements took place during or shortly before the intrusion of the dolerite. This relationship

between the dolerite and the folded sedimentary rocks, that is, the separation of the two in space, seems to me a very remarkable and important point. In the extreme north-west of the area occupied by the rocks which form the Zwartebergen and Langebergen, a part of the country which was affected only by the Cederberg movements, and to a very slight extent by them, the dolerite dykes extend outward from the great area occupied by the intrusive masses in the Karroo, into the older rocks* ; and again in Pondoland, where the lowest member of the Cape System lies nearly horizontally, the dolerite has invaded it. These facts appear to me to confirm the supposition that the dolerite intrusions could not approach the rocks that were being folded, or which had just been folded. It is not improbable that the dolerite, which is so extensively spread through the rocks between Bushmanland and Natal, and which everywhere presents a striking uniformity in petrographical character, was intruded during one period, the limits of which are of course difficult to determine, but which lay between the time of the deposition of the Stormberg Series and that of the Cretaceous rocks of Pondoland, probably much nearer the former than the latter;† for the former were invaded by the dolerites and the latter contain boulders derived from the intrusive rock. If, therefore, the relationship between the Zwartberg folds and the dolerite intrusions is of the nature I have supposed, the date of the dolerite intrusions, approximately determined in Pondoland, gives us an idea as to the date of the formation of the great anticlines of the southern part of the Colony, viz., during the deposition of the Stormberg Series, or between the deposition of the upper part of the Beaufort Series and that of the upper part of the Stormberg. It is impossible at present to fix the date of the Zwartberg movements more closely, or rather the date of their maximum, for they must have lasted a long time geologically speaking.

The question of the former western limits of the Stormberg Beds is of great interest, but there is no direct evidence to decide it. At the present day the Stormberg Beds do not occur to the west or south-west of Steynsburg, but they must formerly have extended beyond

* A dyke of dolerite some fifteen miles long traverses the Dwyka Series on Beukes Fontein in the western or Ceres Karroo, where the Series has been tilted to the east by the same earth-movements that completed the Cederberg anticline. This dyke is some forty miles distant from the dolerite area of the Roggeveld and Nieuweveld.

† It seems likely that the intrusion of the dolerite was connected with the volcanic phenomena of the Drakensberg, which belong to the latest stage of the Stormberg Series. For a discussion of the volcanic and intrusive rocks of the Drakensberg, see E. H. L. Schwarz on "The Geology of Matatiele," Ann. Rep. Geol. Comm. for 1902.

their present outcrops. It is probable that the great accumulations of volcanic rocks, which lie above the ordinary sediments of the Stormberg Series in the Drakensberg and Basutoland, never extended much further west than Molteno, for the volcanic pipes or necks of the type of those of the Drakensberg have not been found west of that neighbourhood. These volcanic rocks have thickened the Stormberg Series in the east, and have also protected the underlying sediments, so that west of the Molteno district the Stormberg Beds have disappeared much more rapidly and completely than east of it. It is quite possible on this view that the Stormberg Beds once extended to the Roggeveld escarpment, and that when the uplift, which produced the main divide of the Colony, took place, the water which fell upon the newly uplifted land flowed in general north-west and south-east directions over a surface composed of the Stormberg Beds. It is certain that a great thickness of rock must have been removed from the Nieuweveld since the watershed was made. If we are right in our conclusion that the Zwartberg movements took place during the deposition of the Stormberg Series, it follows that the production of the main watershed of the land which resulted from the emergence of those deposits from the water in which they were laid down, was posterior to the production of the great southern anticlines.

After these anticlines rose from the water, they lost a vast amount of their substance by the ordinary atmospheric agencies. This process went on for long ages before a record was preserved of the events which took place during this great period of denudation in the south of the Colony. This record is contained in the deposits of the Uitenhage Series, the remnants of which are scattered widely between Algoa Bay, or even further east, and the town of Worcester. Near the towns of Worcester and Robertson the conglomerates of the Uitenhage Series rest directly upon the Malmesbury Beds and also upon the Ecca or possibly higher Beds of the Karroo System, which are faulted down against the pre-Cape rocks, proving that before the conglomerate was formed some 12,000 or 15,000 feet of rock had been removed by denudation on the upthrown side of the Worcester fault.*

The Uitenhage Beds which are of most importance to us in the present connection are the conglomerates, sandstones, and shales,

* E. H. L. Schwarz, *Ann. Rep. of Geol. Comm.* for 1896, p. 29. Further accounts of this fault east of Worcester will be found in the Reports for 1897, App. II. and III. ; for 1898, App. III. and V. The estimate of 12,000 feet is obtained by adding up the thicknesses of the Cape System (10,000 feet) and the part of the Karroo System (2,000 feet at least) which have certainly been removed from the area immediately north of the Worcester fault.

which partly fill the depressions between the Zwarteborgen and Langebergen, and similar depressions south of the latter range. These rocks extend in places to a level below that reached by the present river valleys. The Gamka River, for instance, south of Calitzdorp, runs across these rocks, and its tributary the Oliphant's River has the Uitenhage Series for its bed rock for a considerable distance. South of Herbertsdale sandstones belonging to the Uitenhage Series form the bed of the Gouritz River for some few miles. Near Mossel Bay the conglomerates at the base of the Series lie below sea-level; and at Swellendam their base was not reached by a bore hole put down to a depth of 800 feet below the present surface. The evidence afforded by the Uitenhage Series proves, that before these rocks were formed there were deep longitudinal valleys in the south of the Colony, and that the valleys north and south of the Langebergen were not directly connected as at present by a river traversing the latter, for there is no ancient transverse valley in the Langebergen, filled up with Uitenhage deposits. This absence of all traces of pre-Uitenhage transverse valleys in the Zwarteborgen and Langebergen, together with the distinct evidence of longitudinal valleys, which were eroded relatively more deeply than the present valleys, affords strong evidence against the view that the Gamka and other rivers from the Karroo were antecedent to the mountain ranges; in other words, these rivers did not cut their valleys down through the slowly rising mountains.

The lowest points of the Zwarteborgen and Langebergen now rise considerably higher than the highest level of the areas formed by the Uitenhage rocks, but these have suffered a great decrease in area and thickness during the lapse of time from their formation to the present day, during which it is very improbable that they were again depressed below sea-level. It seems likely that they once partially buried the Langebergen and Zwarteborgen under the load of debris derived from these ranges, and, in the later stages of their deposition, from the country to the north which is now the Karroo. The result of this filling up of the pre-Uitenhage inequalities of surface was, that the rivers which were flowing southwards from the then recently formed watershed flowed south over the present position of the Zwarteborgen, across the area of deposition as this gradually became dry land. Whether the rivers from the southern flank of the watershed formerly discharged into the estuaries and sea, in which the Uitenhage Series were being deposited, further east than the present Oudtshoorn district or in that district will be a difficult point to prove. It is probable, however, that in the later part of the Uitenhage period the rivers did enter the area between the Zwarteborgen and Langebergen.

The striking regularity of the southern rivers in maintaining their channels across the diversified surface south of the Karroo is strong evidence in favour of the view that the general slope of the new land formed by the rising surface of Uitenhage rocks was, generally speaking, in direct continuity with the southern slope of the pre-existing watershed to the north. It is, in fact, probable that the rising of the southern part of the slope was but the accompaniment of the later history of the formation of that watershed and its southern drainage slope.

The published descriptions of the Uitenhage Series* plainly show that the earth movements which have affected the southern part of the Colony since their deposition were insignificant when compared with the Zwartberg movements, and at the same time that they produced a certain amount of difference in level in different parts of the area affected. The Oudtshoorn area has been less affected than the area south of the Langebergen. In Riversdale, for instance, the observed dips in the Uitenhage River beds rise to 20° or even more, and the direction of dip is generally toward the north or north-north-east, showing that there was a sinking of the Langebergen, or of the country on the southern flank of that range relatively to the country still further south, but this alteration of level has had no effect on the course of the Gouritz River, which traverses that part of the country.

After the Uitenhage sediments emerged from the water, the Karroo rivers ran southward from the watershed, across the partially buried mountain chains, and their beds in the lower half of their courses were formed by the Uitenhage rocks. These rocks are of a rather loose incoherent nature as compared with the Karroo rocks and those forming the buried mountain chains, and the rivers must have lowered their valleys comparatively quickly as long as the hard rocks of the unconformably buried ranges were not reached; but after these rocks had been laid bare in the valleys, the rate of the cutting down of the river channels must have decreased. The main river channels, at the time of the first exposure of the hard rocks below the Uitenhage Series, must have been well developed, so that the rivers could not find easier paths to the ocean than the courses given them on the emergence of the Uitenhage sediments. It thus came about that the rivers had to cut their valleys in the extremely hard quartzites of the Zwartbergen, Gamka Hills, Langebergen, and other previously buried ranges that lay in their way. We must thus look upon the river system south of the Karroo as a super-

* Ann. Rep. of Govt. Comm. for 1898, App. III., IV. and V.; 1899, App. II.; 1900, App. I.; and 1901, App. I.

imposed one as regards the folded country between the Karroo and the ocean; that is, it worked its way down from the surface (of Uitenhage sediments), upon which the main streams were consequent, to a highly diversified surface, the result of a former period of denudation, so that the rivers which thus maintained their courses came to have no direct relations to the structure of the country over which they ran after the removal of the unconformable Uitenhage rocks. The evidence which allows us to arrive at this conclusion is almost entirely derived from the remnants of the Uitenhage sediments, which once stretched much further in every direction than they do now. If we, in imagination, remove these remnants of Uitenhage rocks we do not make a profound alteration in the structure of the country between the Karroo and the ocean, we merely lay bare the underlying rocks of the Cape formation, and still older rocks; and one result would be a country like the Ladismith Karroo, and an extension of the George granites and slates to meet the Ruggens of Swellendam; but another result, and the one I wish to call attention to, would be that we should have no clue from the geology of the country to the history of the Karroo rivers.

The rising of the area south of the Karroo, after the deposition of the Uitenhage rocks, altered the relative heights of the watershed and of the southern area, so that at some points the latter is to-day higher than the former, but the elevation of the southern area took place so slowly that the main rivers were able to cut down their valleys as the land rose, and were never dammed back or diverted.

The Buffel's River, which traverses the Zwartebergen below Laingsburg, turns sharply to the east at the confluence of the Touw's River after traversing rather more than half the distance between the Zwartebergen and the Langebergen, and then flows through the latter range together with the Gamka River. The Buffel's River thus traverses the Langebergen some twenty-five miles further east than would be the case if it had taken a direct course to the sea instead of turning east to join the Gamka. On the theory we have adopted to explain the origin of the Karroo drainage, one would expect the Buffel's River to have flowed across the folded belt south of the Zwartebergen more or less parallel to the Gamka. It is a noteworthy fact that one of the lowest depressions on the crest of the Langebergen is situated just on the line which should, according to the hypothesis, have been taken by the Buffel's River. The depression is Garcia's Pass north of Riversdale. At the present day the Kaffir Kuil's River rises in the Langebergen, near Garcia's Pass, and occupies the position of the lower part of the former course of the

Buffel's River. The diversion of the Buffel's River was brought about by the more rapid erosion of the valley of the Gamka, which enabled the tributary of the latter from the west to cut back the divide between the Gamka and Buffel's Rivers to such an extent that the latter river deserted its old course and flowed into the Gamka. The level of the Garcia Pass is about 1,000 feet above the present level of the Buffel's River at the point where it changes its direction, and the diversion must have taken place a very long time ago. Examples of change in direction of rivers owing to the encroachment of a lateral stream, or in the language of the American geographers, the beheading of rivers, are to be found elsewhere in the Colony. One very clear case is that of the Drie Hoek's River in Clanwilliam which flows eastward from the Cederberg anticline, and which formerly ran across the escarpment of the Bokkeveld and Witteberg beds through Nieuwe Gift into the Kruis River, but a north branch of the Matjes River, working its way along the soft Bokkeveld shales, has captured the Drie Hoek's River, and the former eastward course of the latter is now indicated by a deep depression in the escarpment, a wind gap of the Americans. In this case the cause of the diversion is clear, the soft shales of the Bokkeveld Series yielded easily to the encroaching stream so that the Drie Hoek's River was forced to flow down that stream instead of maintaining its former valley across the harder beds of the upper part of the Bokkeveld Series. In the case of the Buffel's River the diversion is so old that we cannot know exactly what the determining factors were. The Langebergen evidently made it sufficiently difficult for the river to cut down its valley across the range, but whether the lateral affluent of the Gamka at the time of the diversion ran over the Uitenhage Series, or whether the river bottom had reached the underlying Bokkeveld Beds, is now impossible to find out.

From an inspection of the maps it is probable that the Traka has had a history somewhat similar to that of the Buffel's River, and has been captured by the Oliphant's River. Whether the Meiring's Poort River is another victim of the Oliphant's River is as yet uncertain; the Wagonpad's Nek in the Kamnassie Range, and a favourably situated depression in the Outiniqua's, point to that being the case, and the future examination of the country will decide the matter.

It appears not improbable that the Gouritz River system has developed by the encroachment of the Dwyka and Gamka Rivers and their affluents, which have captured the Buffel's, Meiring's Poort, and Traka Rivers, once streams with independent valleys from the Karroo to the ocean.

Throughout the country south of the Zwartebergen, and to a much smaller extent north of that range, there are scattered the remains of a former widespread plain covered with gravels and alluvial deposits that were formed when the general level of that portion of the country was probably some 800 feet to 1,000 feet lower than at present. These isolated patches of river-borne detritus are now often found to be cemented by iron compounds and silica into ferruginous and silicious rocks. Descriptions of these rocks have been published in the Reports of the Geological Commission, but a full consideration of them as a whole cannot be undertaken until much more is known of their relative heights above the present valley bottoms. We can only conclude that they record a past stage of the development of the river systems, during which the rivers had, in many parts of their courses, approached the limit of downward erosion, and as a consequence were levelling the country near them more rapidly than was possible while they were chiefly engaged in lowering their beds. The surfaces thus produced were gently undulating plains cut out of the softer rocks, the Uitenhage, Bokkeveld, and Witteberg Series, of the country between the mountains composed of the Table Mountain Series. The terraces cut in the latter are frequently seen south of the Langebergen, and are less well developed north of that range. Had this period of low level and great lateral erosion of the rivers continued to the present day, probably the most conspicuous difference in the resulting surface would have been a greater degradation of the mountain ranges by the extension of the terraces than has actually been the case. But after these terraces had been formed, the country was elevated relatively to the ocean, and the downward cutting powers of the rivers therefore restored, with the result that the rivers have cut deeply into the old peneplain, and the latter is only represented by the flat-topped hills capped with the surface quartzites and associated rocks, which are so conspicuous both to the south and north of the Langebergen.

The great bends of the Gouritz River below Herbertsdale, and between the Pogha Hills and Roode Berg, with the remains of the old peneplain still preserved as steep-sided hills some 600 feet to 800 feet high, enclosed by the bends, are an inheritance from this period of lateral erosion. While a river is actively cutting down its bed it does not take a circuitous route to its mouth; but rivers, whose fall is slight, meander considerably in the plains they traverse. The meanderings of the Gouritz, which are now so deeply sunk below the general surface of the country in their neighbourhood, were doubtless formed while the river was flowing

sluggishly over the peneplains cut by itself and its tributaries ; and their shape has been preserved during the period of rapid downward erosion of the river valley since the uplift began which upset the previous conditions. The Gouritz River has not yet reduced the gradient of its valley to such an extent that it can recommence the work of lateral erosion.

The general conclusions to which this enquiry into the history of one of the Karroo River Systems leads may be summarised :—

1. The emergence of land to the south of the present Karroo, due to the Zwartberg earth movements which took place some time between the period of deposition of the upper part of the Beaufort Series and the close of the Stormberg stage. A series of east and west valleys was originated on this land, and these valleys were extensively developed before the Uitenhage Series was formed.

2. The formation of the main watershed of the Colony by the uplift of the deposits of the latter part of the Karroo System ; the uplift gave rise to the southerly drainage system of the Gouph and Mordenaar's Karroo.

3. The filling up of the east and west valleys by the deposits of the Uitenhage period (Lower Cretaceous ?) which buried most of the old surface features south of the Karroo.

4. The emergence of the Uitenhage sediments owing to a continuation of the movement which brought about the formation of the main watershed, and the prolongation of the river valleys south of the watershed across the emerging Uitenhage rocks.

5. The formation of the Gouritz River system by the adjustment of the streams that brought about the confluence of the Dwyka Gamka and Buffel's Rivers, as well as other minor streams.

6. The production of the peneplains, whose traces are found widely spread between the Zwartbergen and the coast, during a period of decreased erosion of the rivers.

7. The renewal of the erosive powers of the rivers, which has caused the cutting up of the old peneplains.

The map of the Gouritz River system, which is appended in order to facilitate the reading of the paper, was kindly drawn up for me by Mr. A. L. du Toit, of the Geological Survey, and is based upon the Surveyor-General's map of 1895. The geological lines are taken from the field maps of Mr. E. H. L. Schwarz and myself. The black dots represent the positions of towns and villages, but their names were omitted, so that the map should not be overcrowded. The patches of high-level gravels and alluvium, capping the remnants of the peneplains mentioned in the paper, are not represented in this map.